OSUN STATE UNIVERSITY, OSOGBO

COLLEGE OF SCIENCE, ENGINEERING AND TECHNOLOGY

FACULTY OF BASIC SCIENCE

DEPARTMENT OF PHYSICS

PHYSICS 101

Lecture Note

PREPARED

By

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COURSE CONTENT

- Space and Time
- Units and Dimension
- Vectors and Scalars
- Differentiation of Vectors
- Displacement, Velocity, Acceleration
- Kinematics
- Newton’s Laws of Motion,
- Inertial Frames,
- Impulse,
- Force and action at a distance
- Momentum Conservation
- Relative Motion
- Application of Newtonian Mechanics
- Equations of motion

SOME REQUIRED BASIC MATHEMATICS IN THIS COURSE

- In Physics, Mathematics knowledge is required and necessary in order to treat and explain many concepts so that their meaning can be clearly explained. Such mathematical tools include Derivatives (i.e. Differentiation, Integration and Trigonometric functions)
- These tools are highlighted below

- **DERIVATIVES**
- When a graph of y = $3x^2$ is plotted, the slope of this plotting is not constant but varies with the value of x.
- But the mathematician showed that it is possible to derive another function of x that will allow us to determine the slope at any value of x.
- The equation derived is called the derivative of the original equation.
- The process of deriving this equation is called Differentiation. In the case at hand, the derivative is represented as $\frac{dy}{dx}$

- Mathematicians have shown that the first derivative of the function y = kx^n is $\frac{dy}{dx} = nkx^{n-1}$

SOME REQUIRED BASIC MATHEMATICS IN THIS COURSE CONTINUED

As examples, let us now find the derivative of the following

1. Find the derivative of $y = 6x^3$

Then the derivative $\frac{dy}{dx}$ is $= 18x^2$

Find the derivative of $y = 3x^4 + 4x^3 + 2x^2 + 5x$

The derivative is $\frac{dy}{dx} = 12x^3 + 12x^2 + 4x + 5$

Below are the common derivative of some functions

(1) $y = \cos x$ $\frac{dy}{dx} = -\sin x$

(2) $y = \sin x$ $\frac{dy}{dx} = \cos x$

(3) $y = A\cos bx$ $\frac{dy}{dx} = -Ab \sin b x$

(4) $y = A\sin bx$ $\frac{dy}{dx} = Ab\cos bx$

SOME BASIC MATHEMATICS REQUIRED IN THIS COURSE CONTINUED

Integration

This is the reverse of differentiation. Integration is denoted by the sign of ∫. Mathematicians have shown that

$$\int wx^b \, dx = \frac{w}{b+1} x^{b+1} + c$$

For example

$$\int 12 x^3 \, dx = \frac{12}{4} x^4 + c$$

A special integration is that of

$$\int \frac{1}{x} \, dx = \log_a x + c$$

The above is the general rule in which other common integration obey.

Practice Questions

(a) The distances covered by a body in time t is given by $s = ut + \frac{1}{2} a\, t^2$ Where u and a are constants. Find the velocity $v = \frac{ds}{dt}$

(b) Find the magnitude of the force at point $x = 15\ \text{cm}$ if $k = 10500\ \text{N/m}$ when the work done by this force is $W.D = \frac{1}{2} k\, x^2$

Physical Quantities and Units

- We define a **physical quantity** either by specifying how it is measured or by stating how it is calculated from other measurements. For example, we define distance and time by specifying methods for measuring them, whereas we define average speed by stating that it is calculated as distance traveled divided by time of travel.
- Measurements of physical quantities are expressed in terms of **units,** which are standardized values. For example, the length of a race, which is a physical quantity, can be expressed in units of meters (for sprinters) or kilometers (for distance runners).
- Without standardized units, it would be extremely

TYPES OF SYSTEM OF UNITS

There are two major systems of units used in the world:

- SI units (also known as the metric system) and
- English units (also known as the customary or imperial system).
- English units were historically used in nations once ruled by the British Empire and are still widely used in the United States.
- English units may also be referred to as the foot–pound–second (fps) system, as opposed to the centimeter–gram–second (cgs) system. You may also encounter the term SAE units, named after the Society of Automotive Engineers. Products such as fasteners and automotive tools (for example, wrenches) that are measured in inches rather than metric units are referred to as SAE fasteners or SAE wrenches.
- Virtually every other country in the world now uses SI units as the standard;
- the metric system is also the standard system agreed upon by

SI Units: Base and Derived Units

- In any system of units, the units for some physical quantities must be defined through a measurement process. These are called the **base quantities** for that system and their units are the system's **base units.**
- All other physical quantities can then be expressed as **algebraic combinations** of the base quantities. Each of these physical quantities is then known as a **derived quantity** and each unit is called a **derived unit**.
- The choice of base quantities is somewhat arbitrary, as long as they are independent of each other and all other quantities can be derived from them. Typically, the goal is to choose physical quantities that can be measured accurately to a high precision as the base quantities.
- The reason for this is simple. Since the derived units can be expressed as algebraic combinations of the base units, they can only be as accurate and precise as the base units from which they are derived.
- Based on such considerations, the International Standards Organization recommends using seven base quantities, which form the International System of Quantities (ISQ).

- **Table 1:** The Seven Base Units

SN	ISQ Base Quantity	SI Base Unit	**SI Base Unit Abbreviation**
1	Length	**meter**	**m**
2	Mass	**kilogram**	**kg**
3	Time	**second**	**s**
4	Electrical current	**ampere**	**A**
5	Thermodynamic temperature	**kelvin**	**K**
6	Amount of substance	**mole**	**mol**
7	Luminous intensity	**candela**	**cd**

DERIVED QUANTITIES AND DERIVED UNITS

You are probably already familiar with some derived quantities that can be formed from the base quantities as shown in Table 2

SN	Derived Quantity	Process of Derivation	Derived Unit	Derived Unit Abbreviation
1	Area	Length x length	meter x meter	m^2
2	Volume	Length x length x length	kilogram	m^3
3	Speed	Length /time	meter per second	m/s
4	Density	Mass/volume	kilogram/cubic meter	kg/ m^3
5	Angle	Arc length/radius	radian	rad
6	Mass flow rate	Mass/time	kilogram/second	kg/s
7	Volume flow rate	Volume/time	cubic meter/second	m^3/s
8	Electric Charge	Ampere x time	ampere second	A.s
9	Mass flux density	Mass/volume x time	kilogram/ cubic meter x second	Kg/ m^3 x s
10	Velocity	Length in particular direction / time	meter/second	m/s

- Student should be able to come up with other derived quantities
- In conclusion, the point here is that every physical quantity can be derived from the seven base quantities in Table 1, and the units of every physical quantity can be derived from the seven SI base units.

Metric Prefixes

- SI units are part of the metric system, which is convenient for scientific and engineering calculations because the units are categorized by factors of 10. Table 3 lists the metric prefixes and symbols used to denote various factors of 10 in SI units. For example, a centimeter is one-hundredth of a meter (in symbols, 1 cm = 10^{-2} m) and a kilometer is a thousand meters (1 km = 10^{3} m). Similarly, a megagram is a million grams (1 Mg = 10^{6} g), a nanosecond is a billionth of a second (1 ns = 10^{-9} s), and a terameter is a trillion meters (1 Tm = 10^{12} m).

Table 3: Metric Prefixes and their Symbols

Prefix	Symbol	Meaning	Prefix	Symbol	Prefix Meaning
yotta-	Y	10^{24}	yocto-	y	10^{-24}
zetta-	Z	10^{21}	zepto-	z	10^{-21}
exa-	E	10^{18}	atto-	a	10^{-18}
peta-	P	10^{15}	femto-	f	10^{-15}
tera-	T	10^{12}	pico-	p	10^{-12}
giga-	G	10^{9}	nano-	n	10^{-9}
mega-	M	10^{6}	micro-	μ	10^{-6}
kilo-	k	10^{3}	milli-	m	10^{-3}
hecto-	h	10^{2}	centi-	c	10^{-2}

- The only rule when using metric prefixes is that you cannot "double them up." For example, if you have measurements in petameters (1 Pm = 1015 m), it is not proper to talk about megagigameters, although In practice, the only time this becomes a bit confusing is when discussing masses. As we have seen, the base SI unit of mass is the kilogram (kg), but metric prefixes need to be applied to the gram (g), because we are not allowed to "double-up" prefixes. Thus, a thousand kilograms (103 kg) is written as a megagram (1 Mg) since Incidentally,

Metric systems

- have the advantage that conversions of units involve only powers of 10. There are 100 cm in 1 m, 1000 m in 1 km, and so on.
- Another advantage of metric systems is that the same unit

- **USING METRIC SYSTEM**
- **Example:** Restate the mass 1.93×10^{13}kg using a metric prefix such that the resulting numerical value is bigger than one but less than 1000.

Solution

- Replacing the k in kilogram with a factor of 10^3 , we find that

1.93×10^{13} kg = $1.93 \times 10^{13} \times 10^3$ g = 1.93×10^{16} g

From the table of prefix we see that 10^{16} is between "peta-" (10^{15}) and "exa-" (10^{18}). If we use the "peta-" prefix, then we find that 1.93×10^{16}g = 1.93×10^1 Pg since 16 = 1 + 15. Alternatively, if we use the "exa-" prefix we find that 1.93 x 1016 g = 1.93×10^{-2} Eg since 16 = -2 + 18. Because the problem asks for the

Dimensional Analysis

- The dimension of any physical quantity expresses its dependence on the base quantities as a product of symbols (or powers of symbols) representing the base quantities.
- Table 4 lists the base quantities and the symbols used for their dimension.
- For example, a measurement of length is said to have dimension L or . L^1, a measurement of mass has dimension M or M^1, and a measurement of time has dimension T or T^1
- Like units, dimensions obey the rules of algebra.
- Thus, area is the product of two lengths and so has dimension L^2, or length squared.

- Speed has dimension length over time, L/T or LT^{-1}.
- Volumetric mass density has dimension M/L3 or ML^{-3}, or mass over length cubed.
- In general, the dimension of any physical quantity can be written as $L^a\ M^b\ T^c\ I^d\ \Theta^e\ N^f\ J^g$ for some powers a, b, c, d, e. f and g.
- We can write the dimensions of a length in this form with a = 1 and the remaining six powers all set equal to zero:
- $L^1 = L^1\ M^0\ T^0\ I^0\ \Theta^0\ N^0\ J^0$
- Any quantity with a dimension that can be written so that all seven powers are zero (that is, its dimension is $L^0M^0T^0I^0\Theta^0N^0J^0$) is called **dimensionless** (or sometimes "of dimension 1," because anything raised to the zero

Table 4:

SN	Base Quantity	Symbol for Dimension
1	Length	L
2	Mass	M
3	Time	T
4	Electric Current	I
5	Thermodynamic temperature	Θ
6	Amount of substance	N
7	Luminous intensity	J

- Physicists often use square brackets around the symbol for a physical quantity to represent the dimensions of that quantity. For example, if r is the radius of a cylinder and h is its height, then we write [r]= L and [h] = L to indicate the dimensions of the radius and height are both those of length, or L.
- Similarly, if we use the symbol A for the surface area of a cylinder and V for its volume, then [A] = L^2 and [V] = L^3 . If we use the symbol m for the mass of the cylinder and ρ for the density of the material from which the cylinder is made, then [m] = M and [ρ] = ML^{-3}

IMPORTANCE OF THE CONCEPT OF DIMENSION

The importance of the concept of dimension arises from the fact that any mathematical equation relating physical quantities must be **dimensionally consistent**, which means the equation must obey the following rules:

- Every term in an expression must have the same dimensions; it does not make sense to add or subtract quantities of differing dimension (think of the old saying: “You can’t add apples and oranges”). In particular, the expressions on each side of the equality in an equation must have the same dimensions.
- The arguments of any of the standard mathematical functions such as trigonometric functions (such as sine and cosine), logarithms, or exponential functions that appear in the equation must be dimensionless. These functions require pure numbers as inputs and give pure numbers as outputs.

If either of these rules is violated, an equation is not

- **Checking Equations for Dimensional Consistency**

Consider the physical quantities s, v, a and t with dimensions [s] = L, [v] = LT^{-1}, [a] = LT^{-2} and [t] = T. Determine whether each of the following equations is dimensionally consistent: (a) $s = vt + 0{,}5a\,t^2$; (b) $s = vt + 0.5\,at$; and (c) $v = \sin(at^2/s)$

Solution

There are no trigonometric, logarithmic, or exponential functions to worry about in this equation, so we need only look at the dimensions of each term appearing in the equation. There are three terms, one in the left expression and two in the expression on the right, so we look at each in turn:

[s] = L

[vt] = [v].[t] = = $LT^{-1}.T = LT^0 = L$

(b) Again, there are no trigonometric, exponential, or logarithmic functions, so we only need to look at the dimensions of each of the three terms appearing in the equation:

$[s] = L$

$[vt^2] = [v].[t]^2 = LT^{-1}.T^2 = LT$

$[0.5at] = LT^{-2}.T = LT^{-1}$

None of the three terms has the same dimension as any other, so this is about as far from being dimensionally consistent as you can get. The technical term for an equation like this is nonsense.

$$\left[\frac{at^2}{s}\right] = \left[\frac{qt}{s}\right] = \frac{LT^{-2}T^2}{L} = \frac{L}{L} = 1$$

- (c) This equation has a trigonometric function in it, so first we should check that the argument of the sine function is dimensionless:

$$\left[\sin\left(\frac{at^2}{s}\right)\right] = 1$$

The argument is dimensionless. So far, so good.

Now we need to check the dimensions of each of the two terms (that is, the left expression and the right expression) in the equation:

the operations of calculus on dimensions. We have seen that dimensions obey the rules of algebra, just like units, but what happens when we take the derivative of one physical quantity with respect to another or integrate a physical quantity over another? The derivative of a function is just the slope of the line tangent to its graph and slopes are ratios, so for physical quantities v and t, we have that the dimension of the derivative of v with respect to t is just the ratio of the dimension of v over that of t:

$$\left[\frac{dv}{dt}\right] = \frac{[v]}{[t]}$$

Similarly, since integrals are just sums of products, the dimension of the integral of v with respect to t is simply the dimension of v times the dimension of t:

$$\left[\int v\,dt\right] = [v],[t]$$

By the same reasoning, analogous rules hold for the units of physical

Scalars and Vectors

- Many familiar physical quantities can be specified completely by giving a single number and the appropriate unit.
- Scalar is a synonym of “number.” Time, mass, distance, length, volume, temperature, and energy are examples of scalar quantities
- Scalar quantities that have the same physical units can be added or subtracted according to the usual rules of algebra for numbers. For example, a class ending 10 min earlier than 50 min lasts . Similarly, a 60-cal serving of corn followed by a 200-cal serving of donuts gives of energy.
- When we multiply a scalar quantity by a number, we obtain the same scalar quantity but with a larger (or smaller) value. For example, if yesterday’s breakfast had 200 cal of energy and today’s breakfast has four times as much energy as it had yesterday, then today’s breakfast has of energy.
- Two scalar quantities can also be multiplied or divided by each other to form a derived scalar quantity. For example, if a train covers a distance of 100 km in 1.0 h, its speed is 100.0 km/1.0 h = 27.8 m/s, where the speed

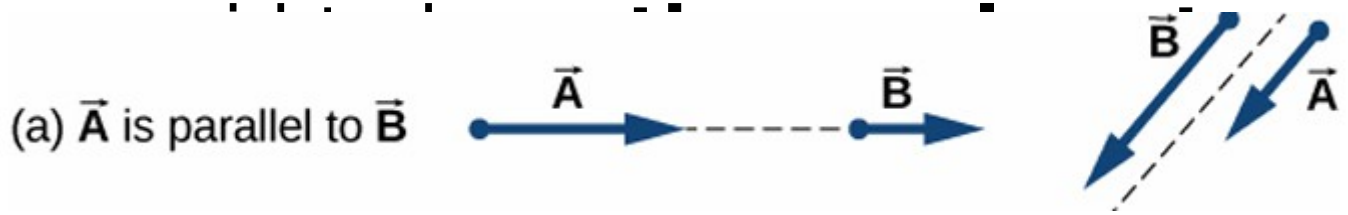
VECTOR

- Many physical quantities, however, cannot be described completely by just a single number of physical units
- Physical quantities specified completely by giving a number of units (magnitude) and a direction are called vector quantities. Examples of vector quantities include displacement, velocity, position, force, and torque
- We can add or subtract two vectors, and we can multiply a vector by a scalar or by another vector, but we cannot divide by a vector. The operation of division by a vector is not defined.
- **TWO METHODS OF SOLVING PROBLEMS IN VECTORS**
- **Vector algebra using a Graphical method**. Graphical method to be aware of basic terms and to develop a qualitative understanding.

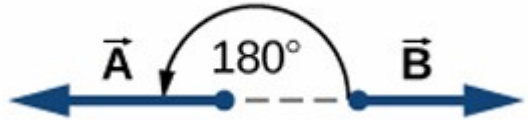
Vector algebra using a Graphical Method.

- Displacement is a general term used to describe a change in position, such as during a trip from your house $\vec{D}$, to your friend's house. the vector, representing your displacement, is drawn as the arrow that originates at point A and ends at point B. The arrowhead marks the end of the vector. The direction of the displacement vector is the direction of the arrow. The length of the arrow represents the magnitude D of vector . Here, D = 6 km. The magnitude of vector $D \equiv |\vec{D}|$ is also indicated by placing the absolute value notation around the symbol that denotes the vector; so, we can write equivalently that
- **To solve a vector problem graphically**, we need to draw the vector to scale. For example, if we assume 1 unit of distance (1 km) is represented in the drawing by a line segment For example
- Suppose you walks from your house A to your friend's house B and then walks back: from your friend's house B to your house A. The magnitude of the displacement vector from A to B is the same as

- In Figure 2.3, vector would be represented by a vector with an origin at point B and an end at point A, indicating vector points to the southwest, which is exactly opposite to the direction of vector . We say that vector **is antiparallel** to vector and write , where the **minus sign indicates the antiparallel direction**.
- **Two vectors** that have **identical directions** are said to be **parallel vectors**-$\vec{A}$;me$\vec{B}$ning, they are para$\vec{A} = \vec{B}$,:o each other.
- **Two parallel vec**t $|\vec{A}| = |\vec{B}|$. **and** **are equal**, denoted by , if and only if they have equal magnitudes
- Two vectors with **directions perpendicular to each** other These relations between

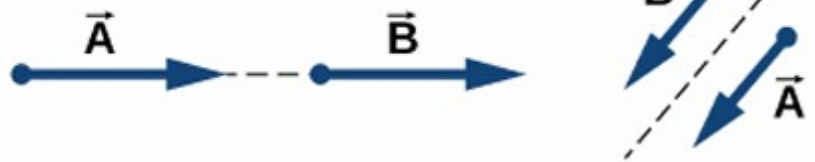


(b) $\vec{A}$ is antiparallel to $\vec{B}$

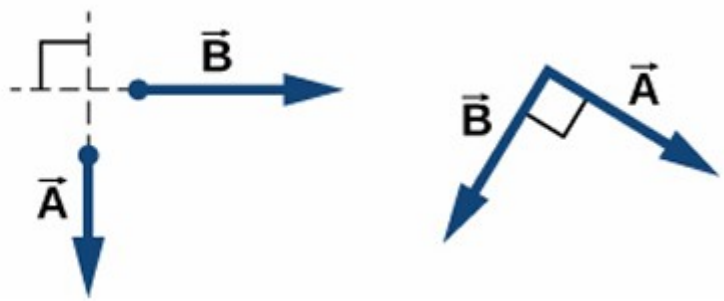


(c) $\vec{A}$ is antiparallel to $-\vec{A}$

(d) $\vec{A}$ is equal to $\vec{B}$



(e) $\vec{A}$ is orthogonal to $\vec{B}$



Algebra of Vectors in One Dimension

- Vectors can be multiplied by **scalars, added to other vectors, or subtracted from other vectors**. We can illustrate these vector concepts using an example
- Suppose your friend Tunde departs from point A (Ayo's house) and walks in the direction to point B (Bola's house), but, along the way, stops to rest at some point C (Comfort's house) located three-quarters of the distance between A and B, beginning from point A. $\vec{\mathbf{D}}_{AC}$
- What is his displacement when he reaches point C? $\vec{\mathbf{D}}_{AB}$, $D_{AB} = 6\,\text{km}$
- We know that if he walks all the way to B, his displacement vector relative to A is , which has magnitude and a direction of northeast. If he walks only a 0.75 fraction of the total distance, maintaining the northeasterly direction, at point C he must be away from the campsite at A. So, his $D_{AC} = 4.5\,\text{km} = 0.75D_{AB}$ $\vec{\mathbf{D}}_{AB}$.

$$\vec{\mathbf{D}}_{AC} = 0.75\vec{\mathbf{D}}_{AB}.$$

- In a vector equation, both sides of the equation are vectors. The previous equation is an example of a vector multiplied by $\alpha = 0.75$, a positive scalar (number) $\vec{\mathbf{D}}_{AC}$. The result, $\vec{\mathbf{D}}_{AB}$, of such a multiplication is a new vector with a direction parallel to the direction of the original vector
- In general, when a vector $\vec{\mathbf{A}}$ is multiplied by a positive scalar α, the result $\vec{\mathbf{B}}$ is a new vector that is parallel to $\vec{\mathbf{A}}$:

$$\vec{\mathbf{B}} = \alpha\vec{\mathbf{A}}.$$

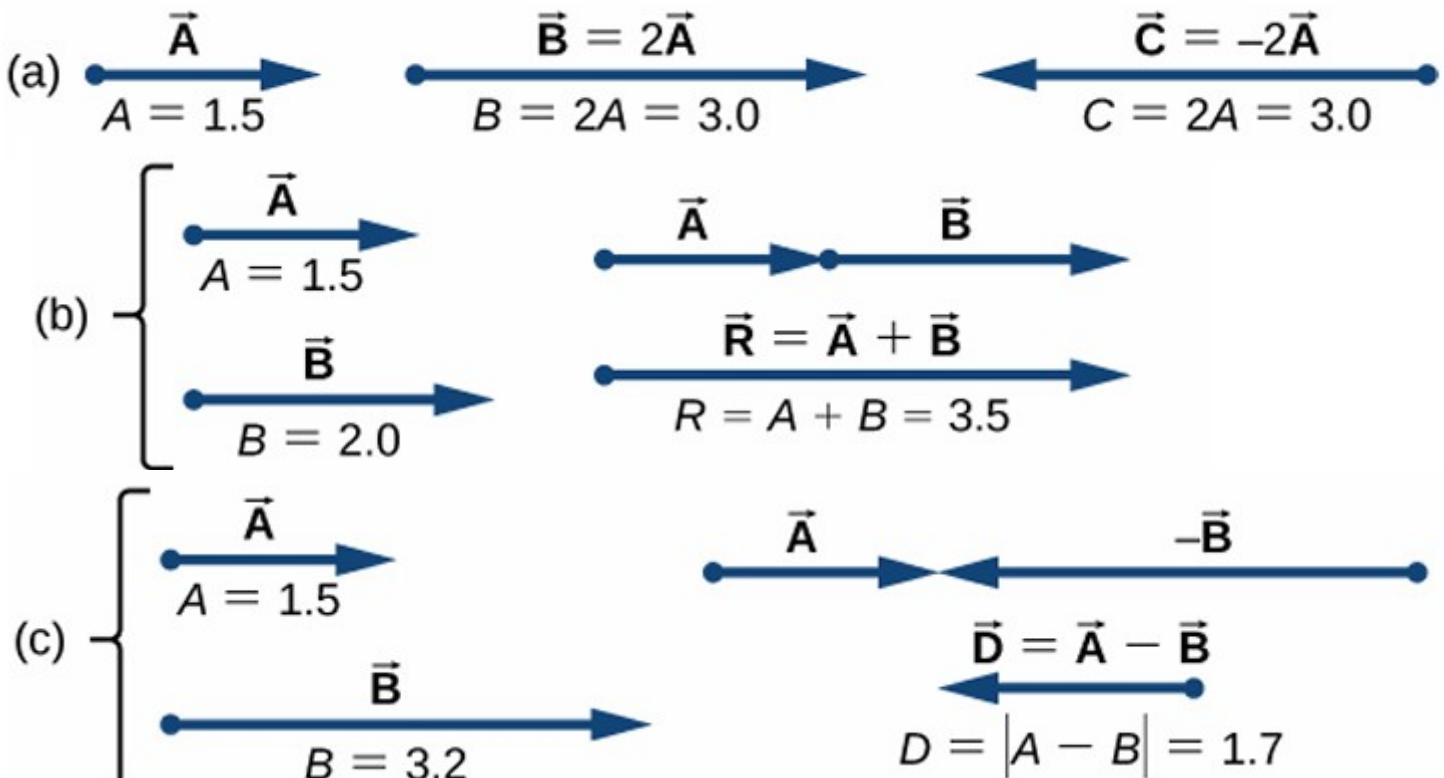
- The magnitude $|\vec{\mathbf{B}}|$ of this new vector is obtained by multiplying the magnitude $|\vec{\mathbf{A}}|$ of the original vector, as expressed by the **scalar equation:**

$$B = |\alpha| A.$$

- In a scalar equation, both sides of the equation are numbers. Equation is a scalar equation because the magnitudes of vectors are scalar quantities (and positive numbers). If the scalar is negative in the vector equation, then the magnitude of the new vector is still given by but the

VECTOR SUM OF ALGEBRA OF VECTORS IN ONE DIMENSION

- The vector sum of two (or more) vectors is called the resultant vector or, for short, the resultant.
- When vectors A and B lie along a line (that is, in one dimension),,their resultant and their difference both lie along the same direction.
- We can il ctors by drawing t e dimension, as shown

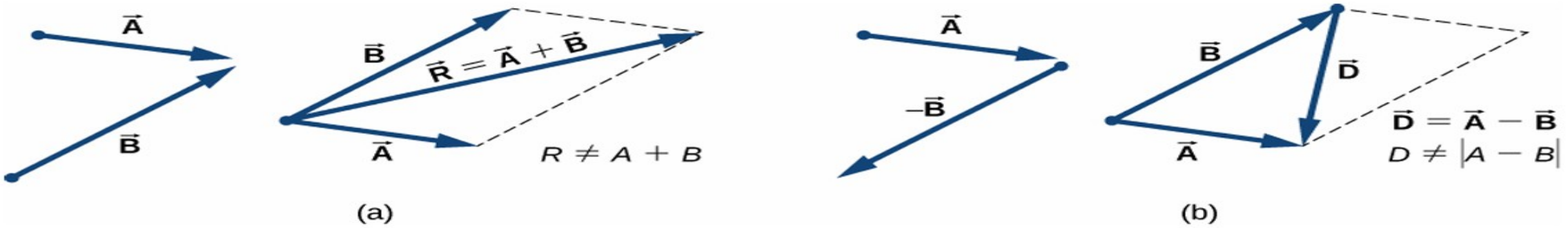


- To illustrate the resultant when vectors $\vec{A}$ and $\vec{B}$ are two parallel vectors, we draw them along one line by placing the origin of one vector at the end of the other vector and $\vec{R} = \vec{A} + \vec{B}$ a head-to-tail fash$\vec{D} = \vec{A} - \vec{B}$eir resultant and their difference . Both lie along the same direction.
- The magnitude of this resultant is the sum of their magnitudes R = A + B.
- When the two vectors vector are antiparallel to each other, we draw them alc$D = |A - B|$ine in either head-to-head fashion or tail-to-tail fashion. The magnitude of the vector difference, then, is the absolute value of the difference of their magnitudes . The direction of the difference vector is parallel to the direction of the longer vector.
- In general, in one dimension, as well as in higher

Algebra of Vectors in Two Dimension

- When vectors lie in a plane—that is, when they are in two dimensions—they can be **multiplied by scalars, added to other vectors, or subtracted from other vectors in accordance with the general laws**
- However, the addition rule for two vectors in a plane becomes more complicated than the rule for vector addition in one dimension.
- We have to use the laws of geometry to construct resultant vectors, followed by trigonometry to find vector magnitudes and directions.
- This geometric approach is commonly used in navigation.
- In this section, we need to have at hand two rulers, a

- For a geometric construction of the sum of two vectors in a plane, we follow the parallelogram rule.
- Suppose two vectors $\vec{A}$ and $\vec{B}$ are at the arbitrary positions shown. Translate either one of them in parallel to the beginning of the other vector, so that after the translation, both vectors have their origins at the same point.
- Now, at the end of vector $\vec{A}$ we draw a line parallel to vector $\vec{B}$ and at the end of vector $\vec{B}$ we draw a line parallel to vector $\vec{A}$ (the dashed lines). In this way, we obtain a parallelogram.
- From the origin of the two vectors we draw a diagonal that is the resultant $\vec{R} = \vec{A} + \vec{B}$ of the two vectors.
- The other diagonal of this parallelogram is the vector $\vec{D} = \vec{A} - \vec{B}$,



- It follows from the parallelogram rule that neither the magnitude of the resultant vector nor the magnitude of the difference vector can be expressed as a simple sum or difference of magnitudes A and B, because the length of a diagonal cannot be expressed as a simple sum of side lengths.
- When using a geometric construction to find magnitudes and , we have to use **trigonometry laws for triangles**, which may lead to complicated algebra. There are two ways to circumvent this algebraic complexity. One way is to use the method of

Algebra of Vectors in Two Dimension CONTINUED

- The other way is to draw the vectors to scale, as is done in navigation, and read approximate vector lengths and angles (directions) from the graphs.
- In this section we examine the second approach.
- If we need to add three or more vectors, we repeat the parallelogram rule for the pairs of vectors until we find the resultant of all of the resultants. For three vectors, for example, we first find the resultant of vector 1 and vector 2, and then we find the resultant of this resultant and vector 3. The order in which we select the pairs of vectors does not matter because the operation of vector addition is commutative and associative (see Equation 2.7 and Equation 2.8). Before we state a general rule

ppose you want to go on vacation trip in Ibadan,

Coordinate Systems and Components of a Vector

- Vectors are usually described in terms of their components in a coordinate system.
- In a rectangular (Cartesian) xy-coordinate system in a plane, a point in a plane is described by a pair of coordinates (x, y). In a similar fashion, a vector **A** in a plane is described by a pair of its vector coordinates.
- The x-coordinate of vector **A** is called its x-component and the y-coordinate of vector **A** is called its y-component.
- The vector x-component is a vector denoted by $\mathbf{A_x}$
- The vector y-component is a vector denoted by $\mathbf{A_y}$.
- In the Cartesian system, the x and y **vector components** of a vector are the orthogonal projections of this vector onto the x- and y-axes, respectively.
- In this way, following the parallelogram rule for vector addition, each vector on a Cartesian plane can be expressed as the vector sum of its vector components:
- $\mathbf{A = A_x + A_y}$
- As illustrated vector **A** is the diagonal of the rectangle where the x-component $\mathbf{A_x}$ is the side parallel to the x-axis and the y-component $\mathbf{A_y}$.is the side parallel to the y-axis. Vector component $\mathbf{A_x}$ is orthogonal to vector component $\mathbf{A_y}$.
- It is customary to denote the positive direction on the x-axis by the unit vector **i** and the positive direction on the y-axis by the unit vector **j** .
- **Unit vectors of the axes**, **i** and **j** , define two orthogonal directions in the plane.
- The x- and y- components of a vector can now be written in terms of the unit vectors of the axes:
- $\mathbf{A_x = A_x i}$
- $\mathbf{A_y} . = \mathbf{A_y j}$

Coordinate Systems and Components of a Vector

- If we know the coordinates **b (x_b, y_b)** of the origin point of a vector (where b stands for “beginning”) and the coordinates **e (x_e, y_e)** of the end point of a vector (where e stands for “end”), we can obtain the scalar components of a vector simply by subtracting the origin point coordinates from the end point coordinates:
- $A_x = x_e - x_b$
- $A_y = y_e - y_b$

- Example
- A mouse pointer on the display monitor of a computer at its initial position is at point (6.0 cm, 1.6 cm) with respect to the lower left-side corner. If you move the pointer to an icon located at point (2.0 cm, 4.5 cm), what is the displacement vector of the pointer
- Solution
- We identify $x_b = 6.0$, $x_e = 2.0$, $y_b = 1.6$ and $y_e = 4.5$, where the physical unit is 1 cm. The scalar x- and y-components of the displacement vector are
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- $D_x = x_e - x_b = (2.0 – 6.0)$ cm = - 4.0cm
- $Dy = y_e - y_b = (4.5 – 1.6)$ cm = 2.9 cm

know the scalar components and of a vector **A**, we can find its magnitude A and its direction angle θ_A.

tion angle

is. The angle is measured in the counterclockwise direction from the +x-axis to the vector (Figure 2.18). Be

$$A^2 = A_x^2 + A_y^2$$

$$A = \sqrt{A_x^2 + A_y^2}$$

This equation works even if the scalar components of a vector are negative. The direction angle of a vector

is defined via the tangent function of angle in the triangle shown